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SUB-FOSSIL SPIDERS FROM HOLOCENE PEAT CORES

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ABSTRACT. An attempt was made to recover identifiable spider sub-fossils from peat cores taken from a post-glacial basin mire in Cheshire, north-west England. Although the features normally required to identify specimens to species level in taxonomic keys were rarely preserved, carapace morphology and cheliceral dentition allowed unequivocal identification to species level in many cases. Current lack of knowledge of the autecology of wetland spiders prevents any conclusion regarding the paleoecological conditions, but the technique could reveal insights into the post-glacial development of the spider faunal assemblage of mires.

Keywords: Spiders, sub-fossils, peat, chelicerae

The value of undisturbed peat deposits as datable sediment is well recognized and the pollen record has been widely used to study the post-glacial vegetational succession, climatic change and the development of agricultural activity during the last 10,000 years (the Holocene epoch). This technique depends on the remarkable resistance of the exine of pollen grains to natural decay and the chemical digestions used in their recovery, together with the taxonomic value of their morphology.

It is also recognized that identifiable (although disarticulated) invertebrate remains can be recovered from peat and other unconsolidated sediments to give useful palaeoecological information. This has been particularly successful in the case of beetles which have a heavily sclerotized exoskeleton that is resistant to decay and bears surface details which enable identification to species level (Coope 1965). Also many beetle species can be linked closely to habitats.

Hofmann (1986) was able to retrieve the head capsules of *Chironomus* larvae by essentially the same method used for pollen analysis. Chironomid larvae and their exuviae would have been particularly numerous in peat and the head capsules are well sclerotized, but as I had observed the rapid disarticulation and decomposition of spiders in pitfall traps when flooding had diluted the preservative, it seemed unlikely that identifiable spider remains would be preserved.

Keys for the identification of spider species have required, among other things, microscopy of the mature female epigyna and male palps. These are not always well sclerotized and would, in any case, require some expertise to recognize if distorted and out of context. However, Coope (1965, 1986) suggested that (in the case of beetles) fragments of cuticle may be identifiable if a well determined reference collection is available. The taxonomic usefulness (at the supra-specific level) of other morphological characters of spiders, has been reviewed by Lehtinen (1978), and these include eye patterns, cheliceral armature and leg structure.

As a reference collection of peatland spiders, appropriate to the study area, was available to the author, he decided to attempt the retrieval of identifiable spider sub-fossils from a species-rich basin mire in Cheshire, England.

METHODS

Site description.—Several samples were taken from the basin mire at Wybunbury Moss National Nature Reserve, Cheshire, England (National Grid Reference: SJ697503), on a transect described by Green & Pearson (1977) and for which a stratigraphy was available. This site is in an area of northwest England which has an oceanic climate and glacial drift geology which have favored the development of numerous basin and raised mires.

Core sampling.—The total depth of peat at the study site is about 5 m, representing accumulation over 5000 years. Sampling depths were 650–750 mm (ca. 500 yr BP), 1150–1250 mm (ca. 1000 yr BP) and 1650–1750 mm (ca. 1400 yr BP), these being the bottom 100 mm of each sequential core. This chronology is derived from the peat accumulation rate suggested for this site by Green & Pearson (1977). The samples were obtained by using a 'Russian pattern' peat sampler (Jowsey 1966; Aaby & Digerfeldt 1986), which produces half-cylinders of peat with a diameter of about 2.5 cm and length of 50 cm (Fig. 1).

Extension rods can allow sampling to more than 5 m if sufficient manpower is available to insert and withdraw the sampler at this depth but, for this single-handed investigation, the maximum depth used was 1.75 m. The surface vegetation was cut away before coring, to minimize the possibility of contamination with recent material.

Aaby & Digerfeldt (1986) described the procedure as shown in the inset cross-sections of Fig. 1: inserting the tool with the cutting shell over the rib and then an anti-clockwise rotation to cut a half-cylinder of peat. Jowsey (1966), on the other hand, performed the reverse action, a clockwise rotation of the cutting shell producing quarter-cylinders of peat on either side of the rib. The method of Aaby & Digerfeldt was used, because insertion with the rib exposed increased the difficulty of penetrating the upper layer which contains tough roots of *Eriophorum* and *Erica*. Samples were returned to the laboratory in 'zip-seal' plastic bags. Should finer stratigraphic resolution be required, then the intact cores can be laid in split plastic pipes and wrapped in cling-film.

Extraction of arthropod remains followed a modified scheme of Coope (1986). Half kilogram aliquots of the peat (larger amounts clogged the sieves) were dispersed in warm water and the coarser material removed by washing through a 2 mm mesh sieve, the material passing through being collected on a 250 µm mesh sieve of 20 cm diameter. The drained, but still damp, product was transferred to a large bowl and mixed thoroughly for several minutes with its own volume of paraffin (kerosene). This can be done by rubber-gloved hand or with a table fork or similar implement.

After decanting as much surplus paraffin as possible (which can be reused), water is added to the mixture, with stirring, to resuspend the sample and fill the container. After ca. 1 hour the sample will have divided into sedimented and floating fractions. The floating fraction is

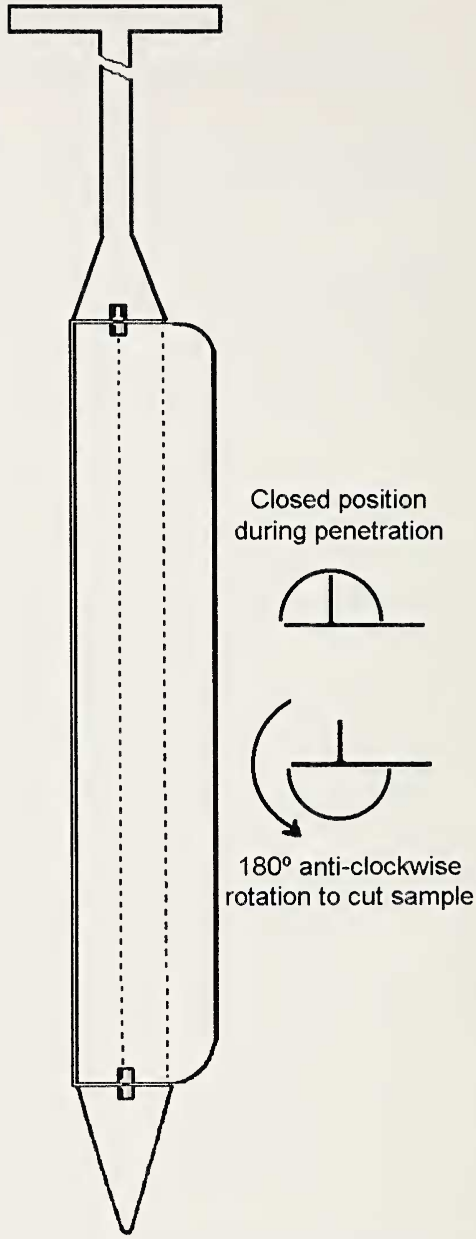


Figure 1.—The 'Russian pattern' peat corer (after Aaby & Digerfeldt 1986).

transferred, either by decanting or spooning off, to another sieve of smaller mesh (I used 53 µm) and most of the residual paraffin can be removed by rinsing with warm water containing detergent.

Coope (1986) then suggested a final rinse in alcohol, followed by microscopy of the extracted material in alcohol. While this may have worked well with the organic silts that

Table 1.—Summary of sub-fossil retrieval. Level 1 samples are from 650–750 mm depth (ca. 500 yr BP); Level 2 samples are from 1150–1250 mm depth (ca. 1000 yr BP) and Level 3 samples are from 1650–1750 mm depth (ca. 1400 yr BP).

	Level		
	1	2	3
Amount of peat processed	5 kg	0.5 kg	0.5 kg
Carapaces	59	5	
Sternums	22	1	1
Chelicerae	130	2	3
Male palps	4	1	
Palpal tibiae			1
Epigyna	1		

he was studying, the floating fraction from partially humified peat samples was often bulky and contained much vegetable material. It was found that resuspending the floating fraction in clean water, after the detergent rinse, caused most of the vegetable matter (sphagnum leaves) to sink.

The new floating fraction was transferred to a petri dish without alcohol treatment for microscopy. Items of interest could be picked from the surface of the water with fine forceps and transferred to alcohol. Best visibility of the sub-fossils (many of which are transparent and pale in color) was obtained by using a mixture of transmitted and incident illumination. A mechanical stage with X and Y axis controls is useful for scanning the surface of the water in a systematic manner.

RESULTS

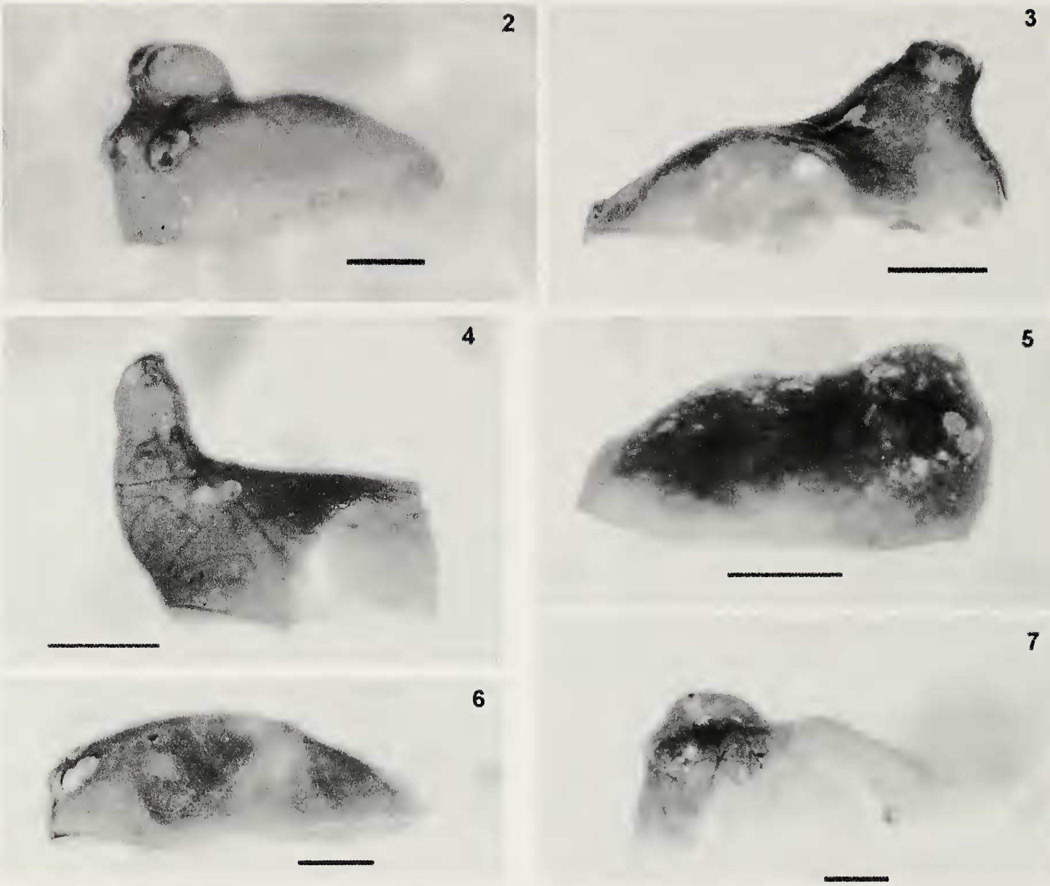
The bulk of the recognizable invertebrate remains consisted of large numbers of oribatid mites, larval head capsules from several insect orders including Odonata and Diptera, beetle elytra and ant mandibles. Spider remains included fragments of carapace, sternum and leg segments, but rather more numerous, and of potential taxonomic use, were individual chelicerae, some complete with articulated fang. The final yield of spider material is shown in Table 1. The data shown in the table might suggest that the occurrence of sub-fossils, especially chelicerae, declined as depth increased. This is probably an artifact, because the sub-samples from the two lower levels were obtained on the first site visit and were the first to be processed. There is a strong subjective impression that the yield improved with experience of the technique, especially at the microscopy stage. Chelicerae, at low magnification, could have been confused with small leg segments, such as trochanters from other arthropod taxa, and ignored. There seems no reason to doubt that similar yields of spider sub-fossils would be available throughout the peat column.

Identification of sub-fossils.—Spider species that were identifiable from sub-fossils came from the following categories: linyphiid males that had distinctive head modifications; larger species from which male palps or female epigynes survived; larger species with distinctive cheliceral dentition; larger species with distinctive carapace features such as eye pattern, hair and bristle distribution, overall size and shape or some combination of these.

Some of the more interesting sub-fossils obtained from the material collected at Wybunbury Moss are shown in Figs. 2–19. It is notable that three small linyphiid species were identified (Figs. 2–4) that did not figure in a recent survey of this site (Felton & Judd 1997): *Hypselistes jacksoni* (O.P.-Cambridge 1902), *Gonatium rubens* (Blackwall 1833) and *Savignya frontata* Blackwall 1833. The males of these species have characteristic carapace profiles, and the first is a mire indicator species. Other linyphiid carapaces were identifiable as species present in the modern fauna (Figs. 5 & 7).

The majority of the remaining carapaces were probably from female linyphiids. Although well preserved, and several seemed conspecific, they could not be positively identified from the reference collection (one is shown in Fig. 6). Leg segments were generally not kept as they were relatively lacking in useful features, but one with some possibility of identification is shown (Fig. 19).

Unequivocal identifications were also possible with the epigynum from *Pardosa pullata* (Clerck 1757) (Lycosidae) (Fig. 13), the male palpal tibia from *Erigone atra* Blackwall 1833 (Linyphiidae) (Fig. 12) and the chelicerae from *Trochosa terricola* Thorell 1856 (Lycosidae) (Fig. 15) and *Drassodes cupreus* (Blackwall 1834) (Gnaphosidae) (Fig. 16). A presumptive identification was possible for several others (Figs. 5, 8–11, 17), assuming that they were species represented in the modern fauna. The bulk of the chelicerae could be



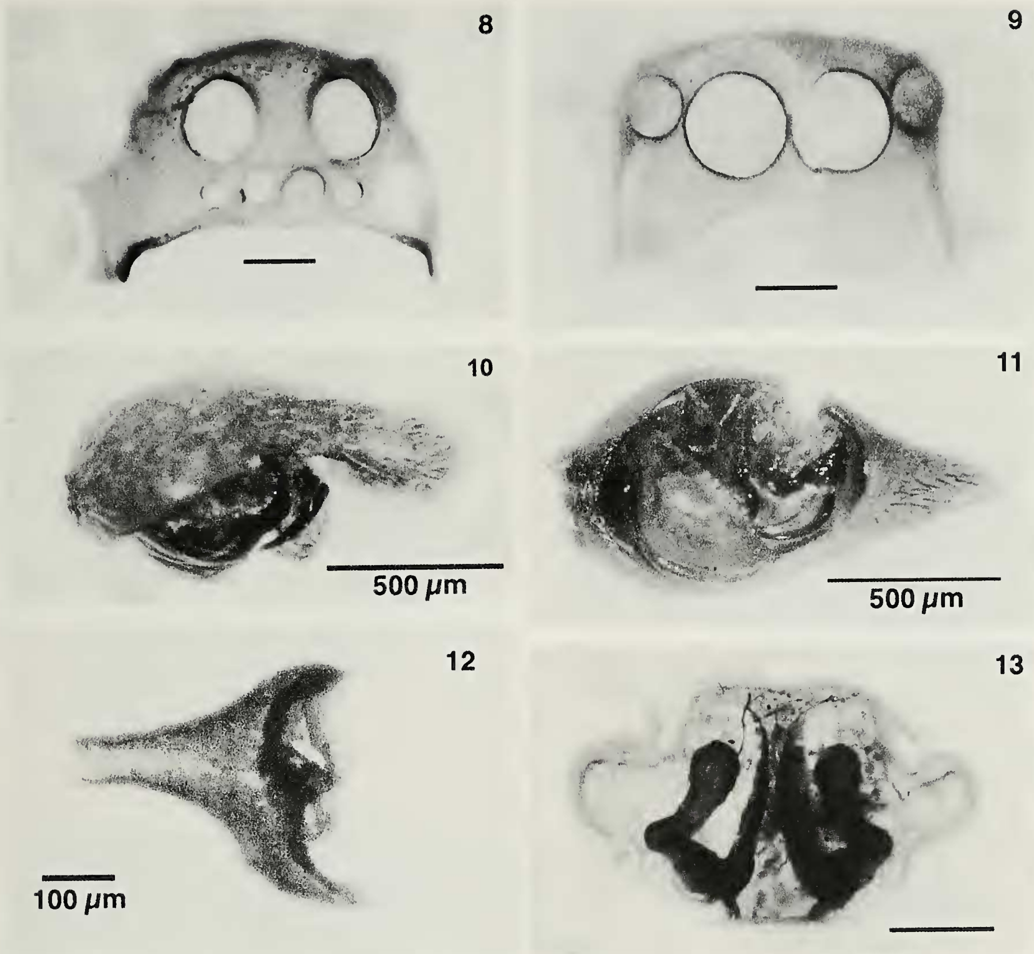
Figures 2–7.—Carapace profiles of sub-fossil linyphiids from peat at Wybunbury Moss level 1: 2. *Hypselistes jacksoni*; 3. *Gonatium rubens*; 4. *Savignya frontata*; 5. *Cnephalocotes obscurus*; 6. Unidentified (see text); 7. *Pocadicnemis pumila*. Scale bars = 200μm.

identified as from the genera *Pardosa* and *Pirata* (Fig. 14), but the cheliceral dentition of these genera is very similar.

DISCUSSION

The retrieval of identifiable spider sub-fossils exceeded initial expectations but much larger samples would need to be processed to give a useful guide to ancient faunas. Many of the mire indicator species contribute less than 1% of the total individuals in the epigeic spider fauna, as judged by present-day pitfall trapping (pers. obs.). There are few references in the literature on the retrieval of spider sub-fossils. Coope (1968), during a study of a sub-fossil insect fauna, encountered 127 spider 'cephalothoraxes' from the processing of 168 kg of organic silt from an exposed terrace in a gravel pit dated to ca. 29,000 yr. BP. These were presumably similar to the carapaces recovered in the present study, but identification to species was not attempted. Girling (1976, 1977, 1978, 1980, 1982), in a series of studies of the insect fauna from excavations of late Neolithic settlements in southwest England dated to ca. 5200 yr. BP, recovered 151 spider sub-fossils from about 400 kg of fen peat. Only one species, *Harpactea hombergi* (Scopoli 1763) (Dysderidae), was identified from these studies, on the basis of eye pattern. This species may have arrived under the bark of the timber used in the construction of the prehistoric trackways. In a later study (Girling 1984) for which quantitative data were not given, fragments of *Dolomedes fimbriatus* (Clerck 1757) (Pisauridae) and *Argyroneta aquatica* (Clerck 1757) (Cybaeidae) were identified.

Although not a primary taxonomic feature, cheliceral dentition was thought to be of tax-

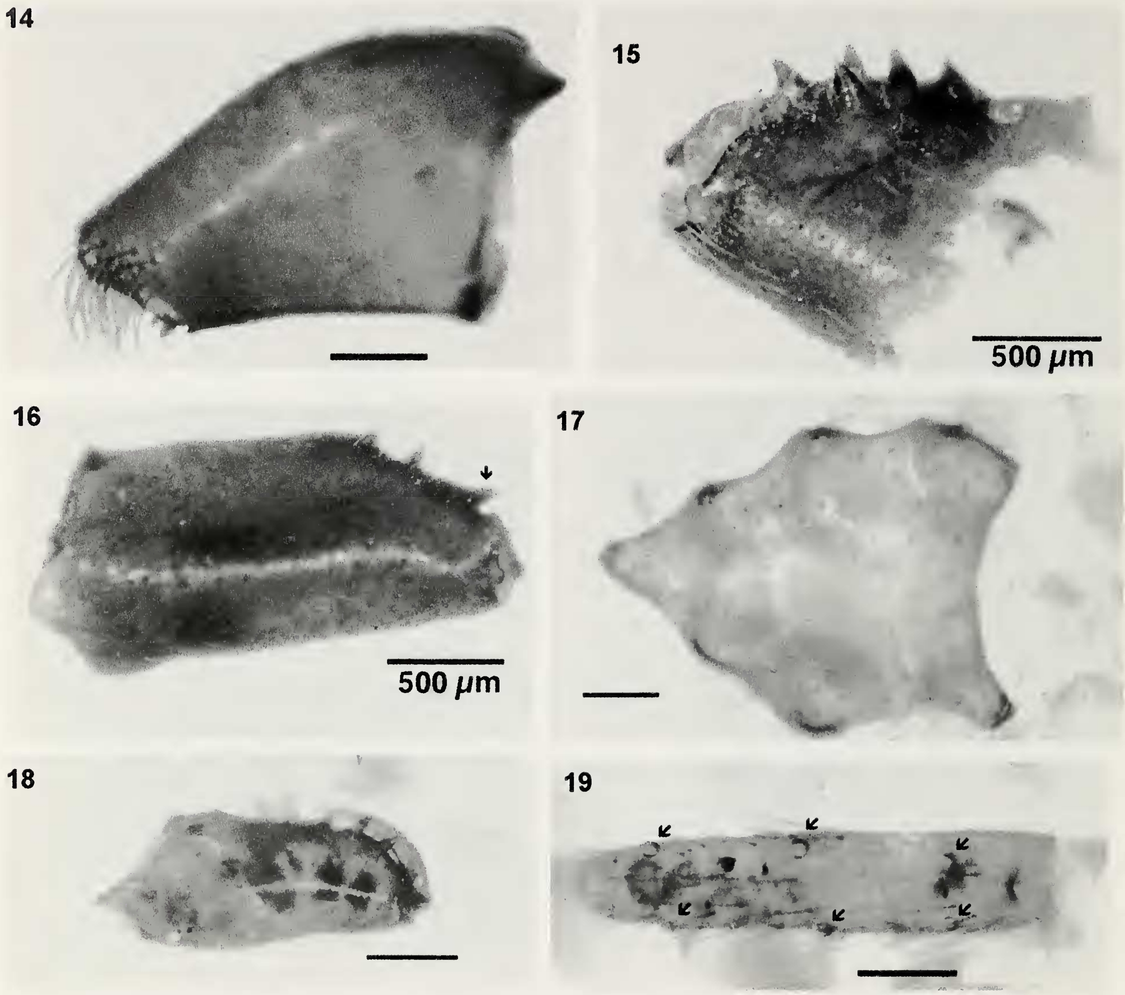


Figures 8–13.—Miscellaneous sub-fossils from peat at Wybunbury Moss: 8. Face of lycosid, possibly *Pirata piraticus*: 9. Face of salticid, possibly *Neon reticulatus*; 10. Male palp similar to *Trochosa terricola*; 11. Male palp similar to *Alopecosa pulverulenta*; 12. Palpal tibia from *Erigone atra* (level 3); 13. Epigynum from *Pardosa pullata*. All from level 1 unless indicated otherwise. Unlabelled scale bars = 200μm.

onomic value by Foelix (1982) and is used to assist in the identification of species in some genera e.g. *Tetragnatha* (see Locket & Millidge 1953). Because spider chelicerae were found to be a regular feature in extracts from peat cores, it might be possible to identify many of them to species by comparison with specimens from an appropriate reference collection. Sub-fossils of molted cuticle would exhibit the features of immature or sub-adult specimens and not relate to the adult morphology, but after study of this material it was evident that most of the sub-fossil material was from adult individuals.

It is doubtful if the species identified from sub-fossils represent their relative abundance in the cursorial fauna at the time of preservation. There may be a bias towards species that live, or build retreats, within the sphagnum layer. A large proportion of the sub-fossils will remain unidentified for lack of distinctive features. In view of these limitations, and the current lack of knowledge of their micro-habitat preferences, it seems that sub-fossil spider fragments would be rarely useful for paleoecological studies, although in the study of Girling (1984) two of the species identified were diagnostic for a fen habitat with open water.

The fact that several species were identified in this small study, goes some way to satisfy the criteria of Foster (1987) who regarded the



Figures 14–19.—Miscellaneous sub-fossils from Wybunbury Moss, level 1: 14. Chelicera from lycosid, probably *Pirata* sp.; 15. Chelicera from *Trochosa terricola*; 16. Chelicera from *Drassodes cupreus*, characteristic conical tooth arrowed; 17. Sternal plate with pigmentation adjacent to coxal articulations, similar to that of *Pirata* sp.; 18. Unidentified chelicera with fang attached: 19. Leg segment with three pairs of spine bases (arrowed). Unlabelled scale bars = 200μm.

availability of post-glacial sub-fossils as one of ten necessary attributes for any invertebrate group being used as an ecological indicator and suggests that the technique might be useful for tracing the history of individual species in the current fauna.

A higher proportion of the material might be identifiable to species if the morphology of chelicerae, sternums and carapaces of the species relevant to bogs was better known. This is complicated by the fact that some features of cheliceral dentition are not constant and that there is sexual dimorphism.

It would be informative to attempt sub-fossil retrieval from greater depth, perhaps to the sedge peats and organic muds that mark the earliest phase of mire development in post-glacial kettle-holes. The sub-fossil spider fauna of raised mires should also be investigated while a few examples of this biome still survive, without major anthropogenic modification or destruction, throughout the Holarctic temperate and boreal regions. It has to be borne in mind that a large volume of peat will need to be processed to provide sufficient material to form the basis of an ecological study.

This might be more easily obtained from exposed profiles in bogs that are being mined commercially.

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